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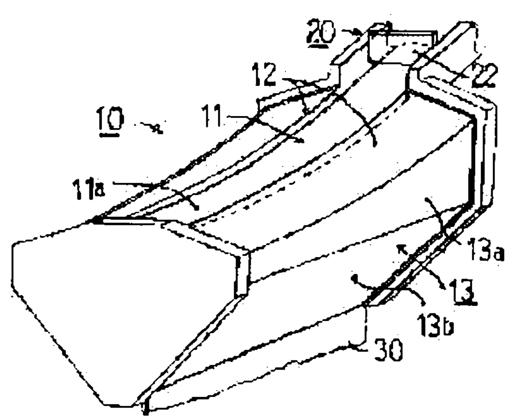
(54) **APPARATUS FOR PRODUCING GLASS PLATE**

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain an apparatus for producing a glass plate having a flow rate controller capable of forming the stable liquid surface of fused glass in the glass supplying groove at the peak parts of the flow rate controller.
SOLUTION: A flow passage floor 11a of the groove bottom surface of the glass supplying groove 11 is formed high at the beginning end in the flow direction of the fused glass and low on the terminal side and is formed at a depression gradient in any positions. The peak parts 12, 12 of the walls on both sides of the glass supplying groove 11 are also formed high at the beginning end in the flow direction of the fused glass and low on the terminal side and is formed at the depression gradient in any positions. The peak parts 12, 12 of the walls on both sides of the glass supplying groove 11 are formed as slopes of the depression gradient which are increasing higher on the inner side in the transverse direction of the groove and decreasing lower on the outer side.



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CLAIMS

[Claim(s)]

[Claim 1] The upper surface has in the crowning the glass supply slot which makes conduit-like [which carried out opening], and makes an overflow weir the both-sides wall crowning of this glass supply slot. And it has the flow regulation object which turned the superficies of a both-sides wall caudad, was made to approach mutually, and was made to end by the soffit. In the manufacturing installation of the glass plate which supplies melting glass continuously from the end of the above-mentioned glass supply slot, is made to carry out an overflow from a both-sides wall top ridgeline, is made to flow down both-sides wall superficies, is made to join by the soffit, and fabricates a glass plate Are high at the start edge side of the flow direction of melting glass in the passage floor used as the groove bottom side of a glass supply slot. The manufacturing installation of the glass plate characterized by it having been low at the termination side and having formed with angle-of-depression inclination in every position, and the both-sides wall crowning of this glass supply slot having also been high at the start edge side of the flow direction of melting glass, having been low at the termination side, and forming it with angle-of-depression inclination in every position.

[Claim 2] The manufacturing installation of the glass plate according to claim 1 characterized by having considered as the inclined plane of angle-of-depression inclination where the both-sides wall crowning of a glass supply slot is high, and becomes low outside by the inside of the flute width direction.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to improvement of the manufacturing installation of the glass plate of a fusion down-draw method.
[0002]
[Description of the Prior Art] The glass-plate manufacturing installation of the conventional fusion down-draw method As shown in drawing 4 , it supplies from the edge of the glass supply slot 2 where the upper surface of the crowning of the flow regulation object 1 carried out opening of the melting glass. Make it flow down on the both-sides wall superficies 4 of the flow regulation object 1, and 4, the melting glass which overflows to both sides is made to join in the soffit of the flow regulation object 1 from the slot side-attachment-wall crownings 3 and 3 of this glass supply slot 2, and the glass plate 5 is fabricated (refer to JP,42-23356,B).
[0003]
[Problem(s) to be Solved by the Invention] In the flow regulation object 1 used by the conventional fusion down-draw method, the groove bottom side by the side of supply of melting glass was located in the glass supply slot 2 formed in the crowning lower than the groove bottom side in the termination of the glass supply slot 2, and a configuration from which the inclination of the groove bottom side of the glass supply slot 2 serves as an elevation angle to the flow direction of melting glass was given to it. Moreover, a flat side configuration which follows the both-sides wall superficies 4 and 4 with the crownings 3 and 3 of the both-sides wall which forms the glass supply slot 2 more nearly perpendicular than the level surface was given.
[0004] It was checked that the oil level of the melting glass in the glass supply slot 2 which has this conventional configuration reacts sensitively to a glass flow rate, glass temperature, and the installation angle of the flow regulation object 1. Consequently, there was fault from which the thickness of the glass plate 5 obtained changes also with change of few operating conditions a lot. Moreover, the amount of overflows of the melting glass exceeding the both-sides wall wall crownings 3 and 3 of the conventional configuration of the glass supply slot 2 had the fault which change of the amount of overflows of the melting glass which exceeds the side-attachment-wall crownings 3 and 3 in near the supply edge of melting glass concentrates and produces, in order to answer quickly to change of the oil-level height of the melting glass which flows the glass supply slot 2.
[0005] Furthermore, it was checked by the oil level of the melting glass near the supply edge of melting glass conventionally [these] with the glass supply slot 2 on the configuration, and the combination of the both-sides wall crownings 3 and 3 that it is easy to generate a surface wave. Since this surface wave changed periodically the amount of overflows of the melting glass exceeding the both-sides wall crownings 3 and 3 of the glass supply slot 2, the fault that the thickness of the glass plate 5 obtained repeated thickness periodically was also accepted.
[0006] Then, if the structure of the flow regulation object which can form the oil level of the melting glass stabilized in the glass supply slot of the crowning of a flow regulation object can be invented, the amount of overflows of the melting glass from a side-attachment-wall crowning will be kept uniform in the direction of the board width, and it will become possible to manufacture continuously the glass plate which has uniform thickness stably and easily.
[0007] this invention was made based on the above-mentioned recognition, and the place made into the purpose is to offer the manufacturing installation of the glass plate equipped with the flow regulation object which can form the oil level of the melting glass stabilized in the glass supply slot of the crowning of a flow regulation object.
[0008]
[Means for Solving the Problem] In order that this invention may attain the above-mentioned purpose, it has in the crowning the glass supply slot which makes conduit-like [in which the upper surface carried out opening]. It has the flow regulation object which made the overflow weir the both-sides wall crowning of this glass supply slot, and turned the superficies of a both-sides wall caudad, was made to approach mutually, and was made to end by the soffit. In the

manufacturing installation of the glass plate which supplies melting glass continuously from the end of the above-mentioned glass supply slot, is made to carry out an overflow from a both-sides wall top ridgeline, is made to flow down both-sides wall superficies, is made to join by the soffit, and fabricates a glass plate In every position, it is high at the start edge side of the flow direction of melting glass, and is low at a termination side, and it forms with angle-of-depression inclination, and the both-sides wall crowning of this glass supply slot is also high at the start edge side of the flow direction of melting glass, is low at a termination side, and forms the passage floor used as the groove bottom side of a glass supply slot with angle-of-depression inclination in every position.

[0009] As mentioned above, since the passage floor of a glass supply slot has an always **** angle of depression to the flow direction of melting glass, it leads promptly the flow of the melting glass in glass supply Mizouchi to the nose of cam of a glass supply slot. And melting glass overflows from a slot side-attachment-wall crowning to both sides as a glass supply slot is gone on. Since angle-of-depression inclination is also given to the both-sides wall crowning of a glass supply slot, the oil-level height exceeding a both-sides wall crowning becomes fixed at the longitudinal direction of a flow regulation object. Thereby, the amount of overflows of the melting glass exceeding a both-sides wall crowning cannot call at the position of a flow regulation object, but can be kept equal. Moreover, the both-sides wall crowning of this invention of a glass supply slot is [the inside of the flute width direction] high, and it has considered as the inclined plane of the angle-of-depression inclination which becomes low outside.

[0010] As mentioned above, it is [the inside of the flute width direction] high, and since the angle-of-depression inclination which becomes low outside is given, the melting glass overflowed and exceeded forms an oil level parallel to a both-sides wall crowning in the both-sides wall crowning of the glass supply slot of a flow regulation object, and flows and falls to it.

[0011] Since the rate of flow of the overflow to the side of the melting glass in a both-sides wall crowning is slower than the rate of flow of the melting glass in a glass supply slot, the state of the flow in a both-sides wall crowning will change slowly rather than the state in a glass supply slot. That is, in case the change of state of flows, such as a temperature change and flow rate change, arises, after the state of the glass flow in a glass supply slot shifts to a new state first, shift of the state of the flow in a both-sides wall crowning comes to be completed. Consequently, the melting glass which flows the glass supply slot on the flow regulation object concerning this invention is maintained at an always stable state, without receiving influence in the state of the flow in a both-sides wall crowning.

[0012]

[Embodiments of the Invention] (A) of the perspective diagram of the flow regulation object which drawing 1 requires for this invention, and drawing 2 is outline explanatory drawing in which (A) - (E) of the C-C line cross section of (A) and drawing 3 setting the side elevation of the flow regulation object of drawing 1 , and (B) in the plan, and (C's) setting it to this invention, and showing qualitatively the relation between the passage floor of a glass supply slot, and a both-sides wall crowning. In drawing 1 and drawing 2 , the glass plate [object / flow regulation] by which 10 was fabricated and a preforming tub and 30 were fabricated for 20 is shown.

[0013] The flow regulation object 10 consists of a configuration which the upper surface had in the crowning the cross-section rectangle conduit-like glass supply slot 11 which carried out opening with the uniform flute width, and made the overflow weir the both-sides wall crownings 12 and 12 of this glass supply slot 11, and turned the both-sides wall superficies 13 and 13 caudad, was made to approach mutually, and was made to end by the soffit.

[0014] Passage floor 11a used as the groove bottom side of the above-mentioned glass supply slot 11 is high at the start edge side of the flow direction of melting glass, is low at a termination side, and is formed with angle-of-depression inclination in every position. Moreover, the both-sides wall crownings 12 and 12 of the glass supply slot 11 are also high at the start edge side of the flow direction of melting glass, are low at a termination side, and are formed with angle-of-depression inclination in every position. Furthermore, the both-sides wall crownings 12 and 12 of the glass supply slot 11 are [the inside of the flute width direction] high, and are made into the inclined plane of the angle-of-depression inclination which becomes low outside.

[0015] Although the both-sides wall superficies 13 and 13 of the glass supply slot 11 have illustrated the case where formed the perpendicular flowing-down sides 13a and 13a in the upper part, and the inner sense flowing-down sides 13b and 13b are formed in the lower part, in drawing 1 and drawing 2 , they may omit and carry out a perpendicular flowing-down side.

[0016] The preforming tub 20 is installed in order to supply melting glass to the glass supply slot 11 of the flow regulation object 10, it gives and installs a beforehand suitable angle of depression in this preforming tub 20, supplies melting glass continuously from a supply pipe 21 into it, pours it uniformly by the straightening vane 22, and forms a steady flow with few rate-of-flow differences of the tub cross direction. If the flow of the melting glass used as this steady flow is led to the glass supply slot 11 as it is, the oil-level height of the melting glass from passage floor 11a of the glass supply slot 11 will not call at a passage position, but will become fixed, and it will become possible to make the stable flat surface which has the same angle of depression as passage floor 11a form of it.

[0017] When a fluid generally flows the passage where the upper surface was opened wide with the free surface, the position of the free surface, i.e., the oil-level height of a fluid, changes with the physical properties of the cross-section configuration of passage, passage inclination, or a fluid a lot. Moreover, a passage configuration is simple, and when the flow direction is set up in the specific direction, it can be dealt with as a problem of the oil-level height of one direction (one dimension) that what is necessary is to evaluate oil-level height only to a flow direction.
[0018] If the oil-level height of the fluid which flows down a plate-like slant face is considered now, an operation of gravity will accelerate below and a fluid will gather the rate of flow. Soon, the frictional force of a fluid and a slant face balances with an operation of gravity, and the rate of flow of a fluid does not change with positions, but comes to carry out regular movement. At this time, the oil-level height of a fluid does not call at a position, but becomes fixed, and is expressed with the following formula.
[0019]
h=(3etaV/rhog-sintheta) 1/3 ... a formula 1 -- here -- eta: -- they are glass viscosity (poise), V:flow rate (cm3 / sec), rho:density (g/cm3), g:gravitational acceleration (cm/sec2), and the degree of tilt angle of theta:slant face
[0020] Next, considering the case where a fluid flows down the passage which has a rectangle cross section, like the above, an operation of frictional force with passage and gravity balances, and the flow of a fluid serves as regular movement. At this time, the oil-level height of a fluid does not call at a position, but becomes fixed, and is expressed with the following formula.
[0021]
h={(9etaV/4rhog-sintheta)a(a2+1)}1/4 ... a formula 2 -- here, it is the aspect ratio (half the price of oil-level height / depth) of a:passage cross section
[0022] As mentioned above, about the stationary flow in the passage of the two above-mentioned kinds of configurations which have the passage inclination theta, the free surface of a fluid will form a flat surface with the inclination theta parallel to a passage floor in the position which separated only oil-level height from the passage floor.
[0023] If this property is used positively, in the steady flow, the free surface with the inclination theta equal to a passage floor can be correctly formed in oil-level height h from the passage floor. Furthermore, although oil-level height h is fluctuated so that a flow rate may be balanced when fluctuating the fluid flow, the configuration of the free surface formed in that case serves as a flat surface with the inclination theta always parallel to a passage floor. Hereafter, the explanation is given.
[0024] If the above-mentioned formulas 1 and 2 are transformed, a relation as shown below can be obtained.
h=K(V/sintheta) n ... a formula 3 -- here, a coefficient K takes the following values
[0025]
case it is monotonous K=(3eta/rhog) n n=1/3 Case of rectangle passage K={(9eta/4rhog)a (a2+1)} n, and n=1/4 -- it is made to flow down to a longitudinal direction, when pouring melting glass on the flow regulation object which has a general configuration, being accompanied by the overflow from the end of the flow regulation object upper part That is, the amount of glass flowing down in each position decreases, so that it progresses to the longitudinal direction of a flow regulation object. Consequently, the oil-level height of melting glass becomes low from the relation which a formula 3 shows.
[0026] Now, if it considers making the passage inclination theta small so that the amount of flowing down of the melting glass which flows to a longitudinal direction may be balanced in each part of a flow regulation object, by making the passage inclination theta small, the rate of flow of melting glass will fall and oil-level height will increase temporarily. That is, if the passage inclination theta is appropriately lessened to the fall of the oil-level height by flow rate reduction, change of the oil-level height on a flow regulation object can be negated according to the effect which raises the oil-level height.
[0027] According to the formula 3, the oil-level height on a flow regulation object can be kept constant by filling the following formula as relation between a flow rate and the passage inclination theta.
Vgamma / sinthetagamma=V 0 / sintheta0 = Regularity ... a formula 4 -- glass flow rate (cm3 / sec) which flows to a longitudinal direction in the position gamma on Vgamma:flow regulation object here
thetagamma: Angle-of-depression inclination V0 of the passage floor in the position gamma on a flow regulation object : The total glass flow rate supplied to a flow regulation object (cm3 / sec)
theta 0 : It is the initial passage inclination of the glass supply edge of a flow regulation object.
[0028] Being all positions and keeping an overflow equal in a longitudinal direction, as a flow regulation object, is called for. In order to satisfy this condition, the flow rate shown by the following formula in the longitudinal direction position gamma needs to flow to a longitudinal direction.
Vgamma= V0 (1-gamma/L) ... a formula 5 -- here, it is the length (cm) of the longitudinal direction of L:flow regulation object
[0029] The following conditions can be acquired by combining a formula 4 and a formula 5.

Sinthetagamma=sin theta 0 (1-gamma/L) ... If passage inclination thetagamma is given to passage in the position gamma of the longitudinal direction of a flow regulation object so that formula 6 formula 6 may be satisfied, in any flow rates, the oil-level height of melting glass will be the longitudinal direction of a flow regulation object, and will become equal. That is, the physical properties of a flow rate, glass viscosity, or others can realize uniform oil-level height, without moving in parallel to a passage floor as a distribution of oil-level height, and producing what bias, although influenced to the oil-level height of melting glass.

[0030] Moreover, about rectangle passage, the passage inclination for acquiring the above-mentioned effect can also be expressed with a formula 7.

sinthetagamma=A-sin theta 0 (1-gamma/L) ... a formula 7 -- here, A is the shape factor of rectangle passage and is given by the following formula

A=a gamma (agamma2+1)/a0 (a02+1)

a0 : The aspect ratio of agamma in the passage cross section of the glass feed zone of a flow-regulation object: According to the aspect ratio formula 7 of the passage cross section in the position gamma on a flow regulation object, change inclination thetagamma of rectangle passage according to the position gamma of a flow regulation object like a formula 6. In addition, passage inclination thetagamma can be changed also by changing the shape factor A of rectangle passage. That is, in rectangle passage, it is changing the cross-section configuration of passage, for example, the depth, and different passage inclination from the passage inclination which a formula 6 gives shows that uniform oil-level height without a bias can be formed on a flow regulation object.

[0031] If the above is summarized, the passage inclination of the passage floor of the glass supply slot of a flow regulation object will give a **** angle of depression to a flow direction.

** Maintain in order so that a formula 6 or a formula 7 may be filled by making the inclination of a mainstream way into an angle of depression. Consequently, a configuration to which the start edge side-stream subgrade of a glass supply slot becomes higher than a termination side-stream subgrade as a passage floor of a mainstream way is given.

** Maintain the inclination of a both-sides wall crowning in order. Consequently, a configuration to which a side-attachment-wall crista-medialis line becomes higher than a side-attachment-wall outside ridgeline is given.

[0032] It is desirable to create a flow regulation object on the above conditions. If a flow regulation object is created on such conditions, since oil-level height will change in parallel to a passage floor to change of a flow rate, temperature, or glass physical properties, the flow rate of the flow exceeding a both-sides wall is always uniformly maintainable. Moreover, the flow exceeding a both-sides wall crowning is stabilized as a steady flow, is served, and changes in parallel [oil-level height] with a passage floor. Consequently, it corresponds slowly to the oil-level height change and the unstable wave motion in a mainstream way, and has the operation which eases an unstable change.

[0033] Based on the above-mentioned principle, the melting glass used as the steady flow is supplied to the leader of the glass supply slot 11 of the crowning of the flow regulation object 10 of this invention which stands in a row in the preforming tub 20. The glass supply slot 11 of the crowning of the flow regulation object 10 concerning this invention is designed so that passage floor 11a may always have angle-of-depression inclination while passage floor 11a by the side of supply of melting glass is located more highly than passage floor 11a in the termination of the glass supply slot 11.

[0034] Moreover, the angle of depression of passage floor 11a of the glass supply slot 11 is equal to the angle of depression of the preforming tub 20 in the joint of the preforming tub 20 and the glass supply slot 11, and it is desirable that ****** gives so that an angle of depression may become small at the nose of cam of the glass supply slot 11. If it does in this way, passage floor 11a of the glass supply slot 11 has an always **** angle of depression to the flow direction of melting glass, and can be made to act so that the flow of the melting glass in the glass supply slot 11 may be promptly led to the nose of cam of the glass supply slot 11.

[0035] It is desirable to suppose that the angle-of-depression change in this passage floor 11a is minute and that it is continuous, and if it does in this way, the flow of the melting glass in the glass supply slot 11 of the flow regulation object 10 will turn into a flow very near the steady flow corresponding to the angle of depression in each position. And since melting glass overflows from the slot side-attachment-wall crownings 12 and 12 to both sides as the glass supply slot 11 is gone on, the amount of flowing down of the melting glass in the glass supply slot 11 decreases as it goes on the glass supply slot 11.

[0036] On the other hand, since the angle of depression of passage floor 11a becomes small as it goes on the glass supply slot 11, it has the operation which makes high the oil-level height of the melting glass which flows down each part, and it works so that the fall of the oil-level height by the amount reduction of flowing down may be compensated. Consequently, the oil level of the melting glass which flows the glass supply slot 11 will form the stable oil level which reaches the longitudinal direction of the flow regulation object 10 which followed the oil level of the melting glass in the preforming tub 20 to the trailer of the glass supply slot 11.

[0037] Thus, from the melting glass which has the stable oil-level height formed in the glass supply slot 11, the melting

glass of a flow rate according to the oil-level height exceeding the both-sides wall crownings 12 and 12 overflows from the glass supply slot 11.
[0038] In the both-sides wall crownings 12 and 12 of the glass supply slot 11 of the flow regulation object 10 concerning this invention, since angle-of-depression inclination is given, the melting glass overflowed and exceeded forms a steady flow, forms an oil level parallel to the both-sides wall crownings 12 and 12, and flows down promptly from the both-sides wall superficies 13 and 13.
[0039] Since the rate of flow of the overflow to the side of the melting glass in the both-sides wall crownings 12 and 12 is fully slower than the rate of flow of the melting glass in the glass supply slot 11, the state of the flow in the both-sides wall crownings 12 and 12 will change slowly rather than the state in the glass supply slot 11. That is, in case the change of state of flows, such as a temperature change and flow rate change, arises, after the state of the glass flow in the glass supply slot 11 shifts to a new state first, shift of the state of the flow in the both-sides wall crownings 12 and 12 comes to be completed. Consequently, the melting glass which flows the glass supply slot 11 on the flow regulation object 10 concerning this invention is maintained at an always stable state, without receiving influence in the state of the flow in the both-sides wall crownings 12 and 12.
[0040] Thus, if the height of the both-sides wall crownings 12 and 12 gives the configuration of the both-sides wall crownings 12 and 12 of the glass supply slot 11 to the oil level of the melting glass on the flow regulation object 10 formed so that it may become [in / any places / only in constant value] low, as for the oil-level height exceeding the both-sides wall crownings 12 and 12, it will become fixed at the longitudinal direction of the flow regulation object 10. Thereby, the amount of overflows of the melting glass exceeding the both-sides wall crownings 12 and 12 cannot call at the position of the flow regulation object 10, but can be kept equal.
[0041] It is made to flow down the melting glass exceeding these both-sides wall crownings 12 and 12 in accordance with the both-sides wall superficies 13 and 13 of the flow regulation object 10, and if the flow regulation object 10 sets caudad and a glass plate 30 is fabricated, the quality glass plate 30 which has uniform thickness can be stably manufactured continuously in the direction of the board width.
[0042] Furthermore, when a glass flow rate and glass viscosity change, based on the property of a steady flow, the oil level of melting glass parallel to passage floor 11a of the glass supply slot 11 is always formed. For this reason, the oil-level height exceeding the both-sides wall crownings 12 and 12 of the glass supply slot 11 becomes equal in any positions of the longitudinal direction of the flow regulation object 10.
[0043] Consequently, it is not necessary to carry out what fine tuning to change of manufacture conditions, and the amount of overflows of the melting glass exceeding the both-sides wall crownings 12 and 12 cannot call at the position of the flow regulation object 10, but can be kept equal, and the quality glass plate 30 which has uniform thickness can always be stably manufactured continuously in the direction of the board width.
[0044] (A) - (E) of drawing 3 is outline explanatory drawing showing qualitatively the relation between passage floor 11a of the glass supply slot 11, and the both-sides wall crownings 12 and 12 in this invention. (A) is the case (however, it is made to approach gently in a termination side) where both are mostly constituted from an parallel-related curve, and the flow regulation object 10 of the above-mentioned example hits this. When (B) constitutes both in a straight line, (C) makes passage floor 11a a curve. When (D) makes passage floor 11a a straight line when the both-sides wall crownings 12 and 12 are made into a straight line, and the both-sides wall crownings 12 and 12 are made into a curve, (E) is the case where both are constituted from a curve, and even if it is in these gestalten, the stability which was excellent about the amount of overflows of melting glass like the above-mentioned example is acquired.
[0045]
[Effect of the Invention] According to this invention, since oil-level height changes in parallel to a passage floor to change of a flow rate, temperature, or glass physical properties, the flow rate of the flow exceeding a both-sides wall is uniformly maintainable. Moreover, the flow exceeding a both-sides wall crowning is stabilized as a steady flow, is served, and changes in parallel [oil-level height] with a passage floor. Consequently, it can respond slowly to the oil-level height change and the unstable wave motion in a glass supply slot, an unstable change can be eased, and the glass plate of uniform thickness can be manufactured in the direction of the board width.
[0046] Moreover, the both-sides wall crowning of this invention of a glass supply slot is [the inside of the flute width direction] high, and an oil level parallel to a both-sides wall crowning can be formed, and the melting glass overflowed and exceeded since it has considered as the inclined plane of the angle-of-depression inclination which becomes low outside can flow and fall, and can manufacture the glass plate of uniform thickness in the direction of the board width.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The perspective diagram of the flow regulation object concerning this invention.
[Drawing 2] For the side elevation of the flow regulation object of drawing 1 , and (B), the plan and (C) are [(A)] the C-C line cross section of (A).
[Drawing 3] (A) - (E) is outline explanatory drawing showing qualitatively the relation between the passage floor of a glass supply slot, and a both-sides wall crowning in this invention.
[Drawing 4] The perspective diagram of the conventional flow regulation object.
[Description of Notations]
10 Flow Regulation Object
11 Glass Supply Slot
11a Passage floor
12 Side-Attachment-Wall Crowning
13 Side-Attachment-Wall Superficies
20 Preforming Tub
30 Glass Plate Fabricated

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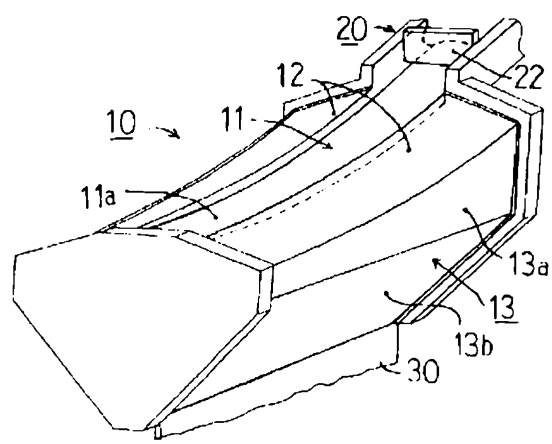
(54)【発明の名称】　ガラス板の製造装置

(57)【要約】

【課題】　流量調節体の頂部のガラス供給溝において安定した溶融ガラスの液面を形成し得る流量調節体を備えたガラス板の製造装置を提供すること。

【解決手段】　ガラス供給溝１１の溝底面となる流路床１１ａを溶融ガラスの流れ方向の始端側で高く、終端側で低く、どの位置でも俯角勾配で形成し、該ガラス供給溝１１の両側壁頂部１２、１２も溶融ガラスの流れ方向の始端側で高く、終端側で低く、どの位置でも俯角勾配で形成した。また、ガラス供給溝１１の両側壁頂部１２、１２が溝幅方向の内側で高く、外側で低くなる俯角勾配の傾斜面とした。



【特許請求の範囲】

【請求項1】　上面が開口した樋形状をなすガラス供給溝を頂部に有し、このガラス供給溝の両側壁頂部を溢流堰とし、かつ、両側壁の外面同士を下方に向けて相互に接近させて下端で終結させた流量調節体を備え、溶融ガラスを上記ガラス供給溝の一端から連続的に供給して両側壁頂部稜線から溢流させ、両側壁外面を流下させて下端で合流させてガラス板を成形するガラス板の製造装置において、

ガラス供給溝の溝底面となる流路床を溶融ガラスの流れ方向の始端側で高く、終端側で低く、どの位置でも俯角勾配で形成し、該ガラス供給溝の両側壁頂部も溶融ガラスの流れ方向の始端側で高く、終端側で低く、どの位置でも俯角勾配で形成したことを特徴とするガラス板の製造装置。

【請求項2】　ガラス供給溝の両側壁頂部が溝幅方向の内側で高く、外側で低くなる俯角勾配の傾斜面としてあることを特徴とする請求項1に記載のガラス板の製造装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、フュージョンダウンドロー方式のガラス板の製造装置の改良に関する。

【0002】

【従来の技術】従来のフュージョンダウンドロー方式のガラス板製造装置は、図4に示すように、溶融ガラスを流量調節体1の頂部の上面が開口したガラス供給溝2の端部から供給し、該ガラス供給溝2の溝側壁頂部3、3から両側へ溢れ出る溶融ガラスを流量調節体1の両側壁外面4、4上を流下させ、流量調節体1の下端において合流させてガラス板5を成形している（特公昭42－23356号公報参照）。

【0003】

【発明が解決しようとする課題】従来のフュージョンダウンドロー方式で用いられる流量調節体1において、その頂部に形成されたガラス供給溝2には、溶融ガラスの供給側の溝底面がガラス供給溝2の終端における溝底面よりも低く位置し、ガラス供給溝2の溝底面の勾配が溶融ガラスの流れ方向に対して仰角となるような形状が与えられていた。また、そのガラス供給溝2を形成する両側壁の頂部3、3は、水平面より垂直な両側壁外面4、4へ連続するような平坦面形状が与えられていた。

【0004】この従来の形状を有するガラス供給溝2における溶融ガラスの液面は、ガラス流量、ガラス温度、流量調節体1の設置角度に対して敏感に反応することが確認された。その結果、わずかな操業条件の変化によっても、得られるガラス板5の厚みが大きく変化してしまう不具合があった。また、ガラス供給溝2の従来形状の両側壁頂部3、3を越える溶融ガラスの溢流量は、ガラス供給溝2を流れる溶融ガラスの液面高さの変化に対して素早く応答するために、溶融ガラスの供給端付近において側壁頂部3、3を越える溶融ガラスの溢流量の変動が集中して生じる不具合があった。

【0005】更に、これら従来形状のガラス供給溝2と両側壁頂部3、3の組合せによって、溶融ガラスの供給端近傍の溶融ガラスの液面には表面波が発生し易いことが確認された。この表面波は、ガラス供給溝2の両側壁頂部3、3を越える溶融ガラスの溢流量を周期的に変化させるので、得られるガラス板5の厚みが周期的に厚薄を繰り返すという不具合も認められた。

【0006】そこで、流量調節体の頂部のガラス供給溝において安定した溶融ガラスの液面を形成することができる流量調節体の構造を発明することができれば、側壁頂部からの溶融ガラスの溢流量を板幅方向に一様に保ち、均一な厚みを有するガラス板を連続して安定かつ容易に製造することが可能になる。

【0007】本発明は、上記認識に基いてなされたもので、その目的とするところは、流量調節体の頂部のガラス供給溝において安定した溶融ガラスの液面を形成することができる流量調節体を備えたガラス板の製造装置を提供することにある。

【0008】

【課題を解決するための手段】本発明は、上述の目的を達成するために、上面が開口した樋形状をなすガラス供給溝を頂部に有し、このガラス供給溝の両側壁頂部を溢流堰とし、かつ、両側壁の外面同士を下方に向けて相互に接近させて下端で終結させた流量調節体を備え、溶融ガラスを上記ガラス供給溝の一端から連続的に供給して両側壁頂部稜線から溢流させ、両側壁外面を流下させて下端で合流させてガラス板を成形するガラス板の製造装置において、ガラス供給溝の溝底面となる流路床を溶融ガラスの流れ方向の始端側で高く、終端側で低く、どの位置でも俯角勾配で形成し、該ガラス供給溝の両側壁頂部も溶融ガラスの流れ方向の始端側で高く、終端側で低く、どの位置でも俯角勾配で形成したものである。

【0009】上記のように、ガラス供給溝の流路床は、溶融ガラスの流れ方向に対して常に順な俯角を有するため、ガラス供給溝内における溶融ガラスの流れをガラス供給溝の先端へすみやかに導く。そして、ガラス供給溝を先へ進むにつれて溶融ガラスは、溝側壁頂部より両側へ溢れ出てゆく。ガラス供給溝の両側壁頂部にも俯角勾配が与えてあるため、両側壁頂部を越える液面高さは、流量調節体の長手方向に一定となる。これにより、両側壁頂部を越える溶融ガラスの溢流量は、流量調節体の位置によらず等しく保つことができる。また、本発明は、ガラス供給溝の両側壁頂部が溝幅方向の内側で高く、外側で低くなる俯角勾配の傾斜面としてある。

【0010】上記のように、流量調節体のガラス供給溝の両側壁頂部には、溝幅方向の内側で高く、外側で低くなる俯角勾配を与えているので、溢れ越える溶融ガラス

は、両側壁頂部に平行な液面を形成して流れ落ちる。

【0011】両側壁頂部における溶融ガラスの側方への溢流の流速は、ガラス供給溝における溶融ガラスの流速よりも遅いので、両側壁頂部における流れの状態は、ガラス供給溝における状態よりもゆっくりと変化することになる。つまり、温度変化、流量変化などの流れの状態変化が生じる際には、まず、ガラス供給溝におけるガラス流れの状態が新しい状態に移行した後に、両側壁頂部における流れの状態の移行が完了するようになる。この結果、本発明に係る流量調節体上のガラス供給溝を流れる溶融ガラスは、両側壁頂部における流れの状態に影響を受けることなく、常に安定な状態に保たれる。

【0012】

【発明の実施の形態】図1は本発明に係る流量調節体の斜視図、図2の（A）は図1の流量調節体の側面図、（B）はその平面図、（C）は（A）のC－C線断面図、図3の（A）～（E）は本発明においてガラス供給溝の流路床と両側壁頂部との関係を定性的に示す概略説明図である。図1および図2において、10は流量調節体、20は予備成形槽、30は成形されたガラス板を示している。

【0013】流量調節体10は、一様な溝幅で上面が開口した断面矩形樋形状のガラス供給溝11を頂部に持ち、このガラス供給溝11の両側壁頂部12、12を溢流堰とし、かつ、両側壁外面13、13を下方に向けて相互に接近させて下端で終結させた形状からなる。

【0014】上記ガラス供給溝11の溝底面となる流路床11aは、溶融ガラスの流れ方向の始端側で高く、終端側で低く、どの位置でも俯角勾配で形成してある。また、ガラス供給溝11の両側壁頂部12、12も、溶融ガラスの流れ方向の始端側で高く、終端側で低く、どの位置でも俯角勾配で形成してある。さらに、ガラス供給溝11の両側壁頂部12、12は、溝幅方向の内側で高く、外側で低くなる俯角勾配の傾斜面としてある。

【0015】ガラス供給溝11の両側壁外面13、13は、図1および図2では、上部に垂直流下面13a、13aを形成し、下部に内向き流下面13b、13bを形成した場合を例示しているが、垂直流下面を省略して実施してもよい。 *

*【0016】予備成形槽20は、流量調節体10のガラス供給溝11に溶融ガラスを供給するために設置されるもので、この予備成形槽20には予め適切な俯角を与えて設置し、その中に供給管21から溶融ガラスを連続的に供給し、整流板22により一様に流し、槽幅方向の流速差が少ない定常流を形成する。この定常流となった溶融ガラスの流れをそのままガラス供給溝11に導けば、ガラス供給溝11の流路床11aからの溶融ガラスの液面高さは、流路位置によらず一定となり、流路床11aと同じ俯角を有する安定な平面を形成させることが可能となる。

【0017】一般に、上面が開放された流路を流体が自由表面を持って流れる場合、その自由表面の位置、即ち、流体の液面高さは、流路の断面形状、流路勾配や流体の物性により大きく変化する。また、流路形状が単純であり、流れの方向が特定の方向に設定されている場合には、流れの方向にのみ液面高さを評価すればよく、1方向（1次元）の液面高さの問題として取り扱うことができる。

【0018】今、平板状の斜面を流下する流体の液面高さを考えると、流体は、重力の作用により下方へ加速され、その流速を増してゆく。やがて、流体と斜面との摩擦力が重力の作用と釣り合って、流体の流速は位置により変化せず、定常運動をするようになる。この時、流体の液面高さは位置によらず一定となり、次の式で表される。

【0019】

$$h=(3\eta V/\rho g\cdot\sin\theta)^{1/3}\quad\cdots式1$$

ここで、

η：ガラス粘度（poise）、V：流量（cm^3/sec）、ρ：密度（g/cm^3）、g：重力加速度（cm/sec^2）、θ：斜面の傾斜角度

である。

【0020】次に、矩形断面を有する流路を流体が流下する場合について考えると、前記と同様に、流体の流れは、流路との摩擦力と重力の作用が釣り合って、定常運動となる。この時、流体の液面高さは位置によらず一定となり、次の式で表される。

【0021】

$$h=\{(9\eta V/4\rho g\cdot\sin\theta)a(a^2+1)\}^{1/4}\quad\cdots式2$$

ここで、a：流路断面の縦横比（液面高さ／流路幅の半値）である。

【0022】上述したように、流路勾配θをもつような上記2種類の形状の流路における定常流れに関しては、流体の自由表面は、流路床から液面高さだけ離れた位置において、流路床と平行な勾配θを持った平面を形成することになる。

【0023】この特性を積極的に利用すれば、定常流においては、流路床に等しい勾配θを持った自由表面を流路床から液面高さhに正確に形成することができるので※

※ある。さらに、流体の流量を増減する場合においては、液面高さhは流量に見合うように増減するのであるが、その場合に形成される自由表面の形状は、常に流路床と平行な勾配θを持つ平面となる、以下、その説明をする。

【0024】上記式1、2を変形すると次に示すような関係を得ることができる。

$$h=K(V/\sin\theta)^n\quad\cdots式3$$

ここで、係数Kは次のような値をとる。

【0025】

平板の場合　　K $(3\eta/\rho g)^{n}$ 、 $n-1/3$

矩形流路の場合　$K=\{(9\eta/4\rho g)a(a^2+1)\}^{n}$ 、$n-1/4$

一般的な形状を有する流量調節体上に溶融ガラスを流す場合、流量調節体上部の一端より溢流を伴いながら長手方向へ流下させることになる。つまり、流量調節体の長手方向へ進むほど、各位置におけるガラス流下量は少なくなる。その結果、式3が示す関係より溶融ガラスの液面高さは低くなってゆく。

【0026】今仮に、流量調節体各部を長手方向に流れる溶融ガラスの流下量に見合うように、流路勾配θを小さくすることを考えると、流路勾配θを小さくすること*

*によって、溶融ガラスの流速が低下し、液面高さは増加する。つまり、流量減少による液面高さの低下に対して、流路勾配θを適切に少なくすれば、その液面高さを高める効果によって、流量調節体上の液面高さの変化を打ち消すことができる。

【0027】式3によると、流量と流路勾配θの関係として次の式を満たすことで、流量調節体上の液面高さを一定に保つことができる。

$$V\gamma/\sin\theta\gamma=V_0/\sin\theta_0=\text{一定} \quad \cdots \text{式4}$$

ここで、

$V\gamma$：流量調節体上の位置γにおいて長手方向に流れるガラス流量（cm^3/sec）

$\theta\gamma$：流量調節体上の位置γにおける流路床の俯角勾配

V_0：流量調節体に供給する総ガラス流量（cm^3/sec）

θ_0：流量調節体のガラス供給端部の初期流路勾配

である。

【0028】流量調節体としては、長手方向において溢流をすべての位置で等しく保つことが求められる。この条件を満足するためには、長手方向位置γにおいて次の式で示す流量が長手方向に流れる必要がある。

$$V\gamma=V_0(1-\gamma/L) \quad \cdots \text{式5}$$

ここで、L：流量調節体の長手方向の長さ（cm）であ※

※る。

【0029】式4と式5を組み合わせることにより、次の条件を得ることができる。

$$\sin\theta\gamma=\sin\theta_0(1-\gamma/L) \quad \cdots \text{式6}$$

式6を満足するように、流量調節体の長手方向の位置γにおいて流路勾配$\theta\gamma$を流路に与えれば、いかなる流量においても溶融ガラスの液面高さは流量調節体の長手方向で等しくなる。つまり、流量、ガラス粘度やその他の物性は、溶融ガラスの液面高さに対して影響するのであるが、液面高さの分布としては流路床に対して平行に移動し、いかなる偏りを生じることなく、一様な液面高さを実現することができる。

【0030】また、矩形流路に関しては、上記効果を得るための流路勾配は、式7で表すこともできる。

$$\sin\theta\gamma=A\cdot\sin\theta_0(1-\gamma/L) \quad \cdots \text{式7}$$

ここで、Aは矩形流路の形状係数であり、次式で与えられる。

$$A=a\gamma(a\gamma^2-1)/a_0(a_0^2-1)$$

a_0：流量調節体のガラス供給部の流路断面における縦横比

$a\gamma$：流量調節体上の位置γにおける流路断面の縦横比

式7によると、矩形流路の勾配$\theta\gamma$は、式6と同様に流量調節体の位置γに応じて変化させる。これに加えて、矩形流路の形状係数Aを変えることによっても、流路勾配$\theta\gamma$を変化させることができる。つまり、矩形流路においては、流路の断面形状、例えば、流路幅を変えることで、式6が与える流路勾配とは異なる流路勾配によって偏りのない一様な液面高さを流量調節体上に形成できることが分かる。

【0031】以上を要約すると、流量調節体のガラス供給溝の流路床の流路勾配は、流れ方向に対して順な俯角を与える。

① 主流路の勾配を俯角として式6若しくは式7を満たすように順に保つ。その結果、主流路の流路床として、ガラス供給溝の始端側流路床が終端側流路床よりも高くなるような形状を与える。

② 両側壁頂部の勾配を順に保つ。その結果、側壁内側稜線が側壁外側稜線よりも高くなるような形状を与え★

★る。

【0032】上記のような条件で流量調節体を作成することが好ましい。このような条件で流量調節体を作成すれば、流量、温度やガラス物性の変化に対して、液面高さが流路床に対して平行に変化するので、両側壁を越える流れの流量を常に一定に維持できる。また、両側壁頂部を越える流れは定常流として安定して振る舞い、液面高さも流路床に平行に変化する。その結果、主流路での液面高さ変化や不安定な波動に対してゆっくりと対応し、不安定な変動を緩和する作用を持つ。

【0033】上記の原理に基いて、予備成形槽20に連なる、本発明の流量調節体10の頂部のガラス供給溝11の始端部へ、定常流となった溶融ガラスを供給する。本発明に係る流量調節体10の頂部のガラス供給溝11は、溶融ガラスの供給側の流路床11aが、ガラス供給溝11の終端における流路床11aよりも高く位置すると共に、流路床11aが常に俯角勾配を有するように設計する。

【0034】また、ガラス供給溝11の流路床11aの俯角は、予備成形槽20とガラス供給溝11の接合部において予備成形槽20の俯角に等しく、ガラス供給溝11の先端に近ずくほど俯角が小さくなるように与えるのが好ましい。このようにすれば、ガラス供給溝11の流

路床11aは、溶融ガラスの流れ方向に対して常に順な俯角を有し、ガラス供給溝11内における溶融ガラスの流れをガラス供給溝11の先端へすみやかに導くように作用させることができる。

【0035】この流路床11aにおける俯角変化は微小で連続的とするのが好ましく、このようにしておけば、流量調節体10のガラス供給溝11における溶融ガラスの流れは、各位置における俯角に対応した定常流にきわめて近い流れとなる。そして、ガラス供給溝11を先へ進むにつれて溶融ガラスは、溝側壁頂部12、12より両側へ溢れ出てゆくので、ガラス供給溝11での溶融ガラスの流下量は、ガラス供給溝11を先へ進むにつれて減少する。

【0036】一方、流路床11aの俯角は、ガラス供給溝11を先へ進むにつれて小さくなるので、各部を流下する溶融ガラスの液面高さを高くする作用を持ち、流下量減少による液面高さの低下を補うように働く。その結果、ガラス供給溝11を流れる溶融ガラスの液面は、予備成形槽20における溶融ガラスの液面に連続した、流量調節体10の長手方向にガラス供給溝11の終端部まで達する安定な液面を形成することになる。

【0037】このようにしてガラス供給溝11に形成される安定な液面高さを有する溶融ガラスからは、両側壁頂部12、12を越える液面高さに応じた流量の溶融ガラスがガラス供給溝11から溢れ出る。

【0038】本発明に係る流量調節体10のガラス供給溝11の両側壁頂部12、12には、俯角勾配を与えているので、溢れ越える溶融ガラスは定常流を形成し、両側壁頂部12、12に平行な液面を形成し、両側壁外面13、13から速やかに流下する。

【0039】両側壁頂部12、12における溶融ガラスの側方への溢流の流速は、ガラス供給溝11における溶融ガラスの流速よりも十分に遅いので、両側壁頂部12、12における流れの状態は、ガラス供給溝11における状態よりもゆっくりと変化することになる。つまり、温度変化、流量変化などの流れの状態変化が生じる際には、まず、ガラス供給溝11におけるガラス流れの状態が新しい状態に移行した後に、両側壁頂部12、12における流れの状態の移行が完了するようになる。この結果、本発明に係る流量調節体10上のガラス供給溝11を流れる溶融ガラスは、両側壁頂部12、12における流れの状態に影響を受けることなく、常に安定な状態に保たれる。

【0040】このようにして形成される流量調節体10上の溶融ガラスの液面に対して、両側壁頂部12、12の高さが一定値だけいかなる場所においても低くなるように、ガラス供給溝11の両側壁頂部12、12の形状を与えると、両側壁頂部12、12を越える液面高さは、流量調節体10の長手方向に一定となる。これにより、両側壁頂部12、12を越える溶融ガラスの溢流量は、流量調節体10の位置によらず等しく保つことができる。

【0041】この両側壁頂部12、12を越える溶融ガラスを流量調節体10の両側壁外面13、13に沿って流下させ、流量調節体10の下方においてガラス板30を成形すれば、板幅方向に均一な厚みを有する高品質のガラス板30を安定にかつ連続して製造することができる。

【0042】更に、ガラス流量やガラス粘度が変化した場合、定常流の性質に基いてガラス供給溝11の流路床11aに平行な溶融ガラスの液面を常に形成する。このため、ガラス供給溝11の両側壁頂部12、12を越える液面高さは、流量調節体10の長手方向のいかなる位置においても等しくなる。

【0043】この結果、製造条件の変化に対していかなる微調整を実施する必要もなく、両側壁頂部12、12を越える溶融ガラスの溢流量は、流量調節体10の位置によらず等しく保つことができ、常に板幅方向に均一な厚みを有する高品質のガラス板30を安定にかつ連続して製造することができる。

【0044】図3の(A)～(E)は、本発明において、ガラス供給溝11の流路床11aと両側壁頂部12、12との関係を定性的に示す概略説明図である。(A)は両者をほぼ平行関係の曲線で構成した場合(但し、終端側では緩やかに接近させる)であり、上記実施例の流量調節体10がこれにあたる。(B)は両者を直線で構成した場合、(C)は流路床11aを曲線とし、両側壁頂部12、12を直線とした場合、(D)は流路床11aを直線とし、両側壁頂部12、12を曲線とした場合、(E)は両者を曲線で構成した場合であり、これらの形態にあっても上記実施例と同様に溶融ガラスの溢流量について優れた安定性が得られる。

【0045】

【発明の効果】本発明によれば、流量、温度やガラス物性の変化に対して、液面高さが流路床に対して平行に変化するので、両側壁を越える流れの流量を常に一定に維持できる。また、両側壁頂部を越える流れは定常流として安定して振る舞い、液面高さも流路床に平行に変化する。その結果、ガラス供給溝での液面高さ変化や不安定な波動に対してゆっくりと対応し、不安定な変動を緩和することができ、板幅方向に均一な厚さのガラス板を製造することができる。

【0046】また、本発明は、ガラス供給溝の両側壁頂部が溝幅方向の内側で高く、外側で低くなる俯角勾配の傾斜面としてあるため、溢れ越える溶融ガラスは、両側壁頂部に平行な液面を形成して流れ落ちることとなり、板幅方向に均一な厚さのガラス板を製造することができる。

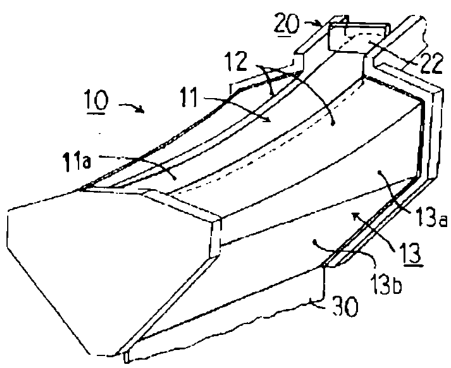
【図面の簡単な説明】

【図1】本発明に係る流量調節体の斜視図。

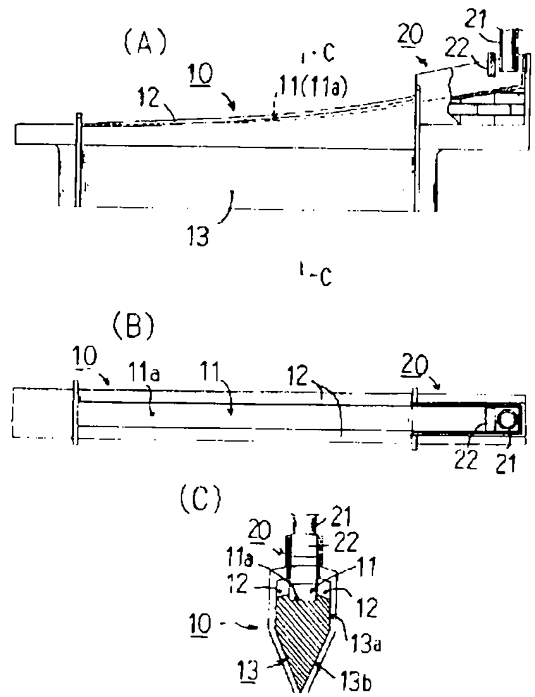
【図2】（Ａ）は図１の流量調節体の側面図、（Ｂ）はその平面図、（Ｃ）は（Ａ）のＣ−Ｃ線断面図。
【図3】（Ａ）〜（Ｅ）は本発明において、ガラス供給溝の流路床と両側壁頂部との関係を定性的に示す概略説明図。
【図4】従来の流量調節体の斜視図。
【符号の説明】

１０	流量調節体
１１	ガラス供給溝
１１ａ	流路床
１２	側壁頂部
１３	側壁外面
２０	予備成形槽
３０	成形されるガラス板

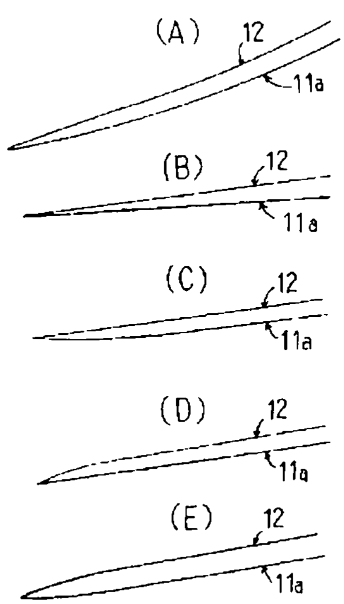
【図1】



【図2】



【図3】



【図4】